CONCLUSIONS

This Nationwide DBP Occurrence Study revealed that many of the high priority DBPs can occur in finished drinking water at levels similar to those of the commonly measured DBPs. For example, iodo-THM levels ranged from 0.2 to 15 μg/L and brominated nitromethane levels were as high as 3 μg/L. In addition, MX levels measured in this study were significantly higher than previously reported. Specifically, MX levels were often above 100 ng/L, with a maximum concentration of 310 ng/L; brominated forms of MX (BMX-1 and BEMX-3) reached 170 and 200 ng/L, respectively. These results suggest that some of the high priority DBPs should be the focus of new health effects research, particularly for the bromonitromethanes that are being shown to be significantly more genotoxic in mammalian cells than MX and most currently regulated DBPs. It has also been hypothesized that the iodinated species may be more carcinogenic than the brominated species. Given the levels of iodo-THMs that can be formed in waters high in bromide/iodide, it is recommended that the iodo-THMs also be targeted for expanded/accelerated health effects studies.

Several haloamides were quantified for the first time in this study and found to be present at levels similar to other commonly measured DBPs (low μg/L levels). This is a new class of DBP that has not been previously measured in treated, potable waters, and may be important due to the levels found.

With respect to treatment processes, we found that the use of ozone removed MX-analogue precursors, and that GAC filters removed MX-analogues via adsorption and/or biodegradation. However, it was also shown that post-chlorination or chloramination following GAC filtration can contribute to MX-analogue re-formation. Chlorine and ClO_2-chlorine were confirmed as the major producers of MX-analogues, as previously observed by Kronberg (1999). MX did not form from ClO_2 disinfection *per se*, rather ClO_2 oxidation did not destroy MX precursors (as ozone, another alternative disinfectant, does). The high concentrations of MX-analogues (>100 ng/L) observed in these water treatment plants were greater than that previously reported. Either previous methods for the detection of MX-analogues (all published concentrations <90 ng/L) may have systematically underestimated the true concentrations, due to degradation of the MX-analogues during lengthy sample storage and processing, or higher concentrations were detected in this study because utilities that treat waters high in TOC and/or bromide were included.

This study has also revealed that some of our previous understanding of the formation and control of DBPs with alternative disinfectants was not complete. For example, it has been assumed from past THM data that alternative disinfectants are a good means of controlling other potentially hazardous, halogenated DBPs. However, the results show here that some DBPs—particularly iodo-THMs and dihaloacetaldehydes—can occur at higher concentrations in treatment plants using alternative disinfectants. Thus, while alternative disinfectants can control the formation of the four currently regulated THMs, they do not necessarily control all halogenated DBPs of concern. Consider that MX was found at its highest level at a treatment plant that disinfected a high-TOC water with chlorine dioxide, chlorine, and chloramines. Alternatively, at another plant that treated the same water with ozone, biodegradation (on GAC filter), and chlorine, halogenated furanone formation was significantly lower. As discussed above, this probably reflects differences in the ability of ClO_2 and ozone—as well as biodegradation and GAC filtration—to destroy MX precursors, which were probably quite high in this high-TOC water.

Many new DBPs were identified through the course of this study. In particular, iodinated acids were identified for the first time, along with a DBP tentatively identified as iodobutanal. Therefore, iodo-THMs are not the only possible iodinated DBPs that can form. Several new brominated acids were also identified, with carbon chain lengths of three and four being common, as well as the presence of diacids and double bonds in their structures. One of the high priority DBPs that was quantified in this study—3,3-dichloropropenoic acid—is an example of a chlorinated, three-carbon acid; it was frequently found in treated waters at levels ranging from 0.4 to 1.5 µg/L in finished waters. Therefore, the presence of haloacids other than the regulated, two-carbon haloacetic acids must be realized.

The stability of DBPs in potable water distribution systems and in simulated distribution system (SDS) tests varied. In most cases where chloramination was used for disinfection, the DBPs were relatively stable. However, when free chlorine was used, THMs and other DBPs, including haloacetic acids, increased in concentration in the distribution system and in SDS testing. Haloacetonitriles generally were stable (at the distribution-system pH levels encountered in this study) or increased in concentration in the distribution system, but many of the haloketones were found to degrade. Halonitromethanes and dihaloacetaldehydes were also generally found to be stable in distribution systems. MX analogues were sometimes stable and sometimes degraded somewhat in the distribution system and during SDS testing. When MX analogues showed some degradation in the distribution system, they were generally still present at detectable levels, indicating that they do not completely degrade. Many times, the brominated analogues of MX (BMXs) were stable in the distribution system.